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THE STUDY OF THE FIBERGLASS FASTENERS IN WALL STRUCTURES

Abstract. The article is devoted to the study of pull-out tests of fiberglass plastic dowels installed in the walls made of lightweight concrete. The authors have undertaken experimental tests of anchors in use on the construction site and conducted analysis of test results.

Keywords: plastic fiberglass, dowel, pull-out tests, masonry walls, elevation of building, lightweight concrete, wall, construction.

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ИССЛЕДОВАНИЕ РАБОТЫ СТЕКЛОПЛАСТИКОВЫХ КРЕПЕЖНЫХ ЭЛЕМЕНТОВ В СТЕНОВЫХ КОНСТРУКЦИЯХ

Аннотация. Работа посвящена исследованию характеристик сцепления композитных стеклопластиковых дюбелей с легким бетоном. Авторами проведены экспериментальные испытания анкеров в натурных условиях на строительной площадке и выполнен анализ результатов испытаний.

Ключевые слова: стеклопластик, дюбель, определение усилия вырыва, кладка, фасад здания, легкий бетон, стена, конструкция.

The wall claddings used as construction solutions today are various in design. It is important that the structural scheme chosen for the constriction project meets certain specifications that define its durability and safety of use. These include:

— energy efficiency;
— bearing load capacity;
— durability.

The search for energy-efficient solutions in wall claddings has conditioned the necessity for two- and three-ply wall constructions, which include an efficient heat insulation layer.

Plaster, add-on air elevations of buildings, or brick facing are used as outer protective and finishing layers. In brick facing, the bearing capacity for thrust and suction, which increases with wind load, is an important element of overall safety and structural reliability.

The load accommodation of this kind, as seen in three-ply cladding structure, is ensured by anchoring brick layers to flooring and load-bearing walls (along the perimeter of all masonry) as well as by linking outer and inner brick layers. This engineering solution is realized through the usage of new elements as ties; the elements themselves, fiberglass dowels have not been fully researched yet.

Proceeding from the literature reviewed within the scope of our study, we have come to the conclusion that the research published on the functioning of fiberglass elements in different walls, has been either insufficient or absent from wider circulation. Thus, an independent research of the operational characteristics of lightweight concrete fiberglass elements [1–3] was conducted on the grounds of the Institute of Civil Engineering in Ural Federal University named after B. N. Yeltsin (the laboratory of Urban Development Department and the Department of Computer-aided Design Systems of Construction Objects) in tandem with the specialists of the Institute of Construction Project and Design Ltd.

(InPAD Ltd). The analysis of load-carrying capacity for fiberglass dowels and their linking with bricks and autoclave gas-and-ash concrete blocks, which we performed within the scope of the scientific sphere, is given further in the article.

Fiberglass dowels of CD2 type and their compatibles are used in constructing outer walls and aimed at ensuring the linking between brick layers of different materials.

The most widely spread type of masonry in the Sverdlovsk region is small-piece gas concrete blocks produced with autoclave hardening in the production and construction society "Teplit Ltd." (further referred to as Twinblock) and an external row of facing silicate bricklayer. A fiberglass dowel is shown in Fig. 1, and the cross-section parameters, as marked in the figure, are given in Table 1 (as given in Tools, Jigs and Fixtures 20994511–001–2009 [4]).

While doing masonry work, dowels are fixed into the brick layering (when constructing inner walls of a building); further on, due to the size ratio between the bricks and the blocks, the dowel remains anchored into the brick joints between layers of blocks. We can observe a similar situation when doing masonry work with scaffolding.

A control lifting jack (adhesion meter) Hydrajaws Model 2000 MG105E (20), with the necessary metering verification certificate, was used in the testing procedure. The control lifting jack (further on referred to as "the tester") was developed specifically to test anchoring strength and pull-out capacity of fastening elements.

The main technical specifications of the device are as follows:

— pull-out capacity range — from 0 to 25 kN;

— calculated load indicator range: 0–5, 0–10, 0–15, 0–20 and 0–25 kN;

— accepted load indicator error ± 2.5 % of the scale range.

Presently, the pull-out tests conducted abroad resort to a uniform methodology, which is detailed in ETAG 001 [5]. It is considered that the method of processing experimental research results given in the aforesaid normative documents fully corresponds to the modern demands of science and thus, is the only one to provide reliable indicators that would characterize the working principles of anchoring fasteners [6]. The

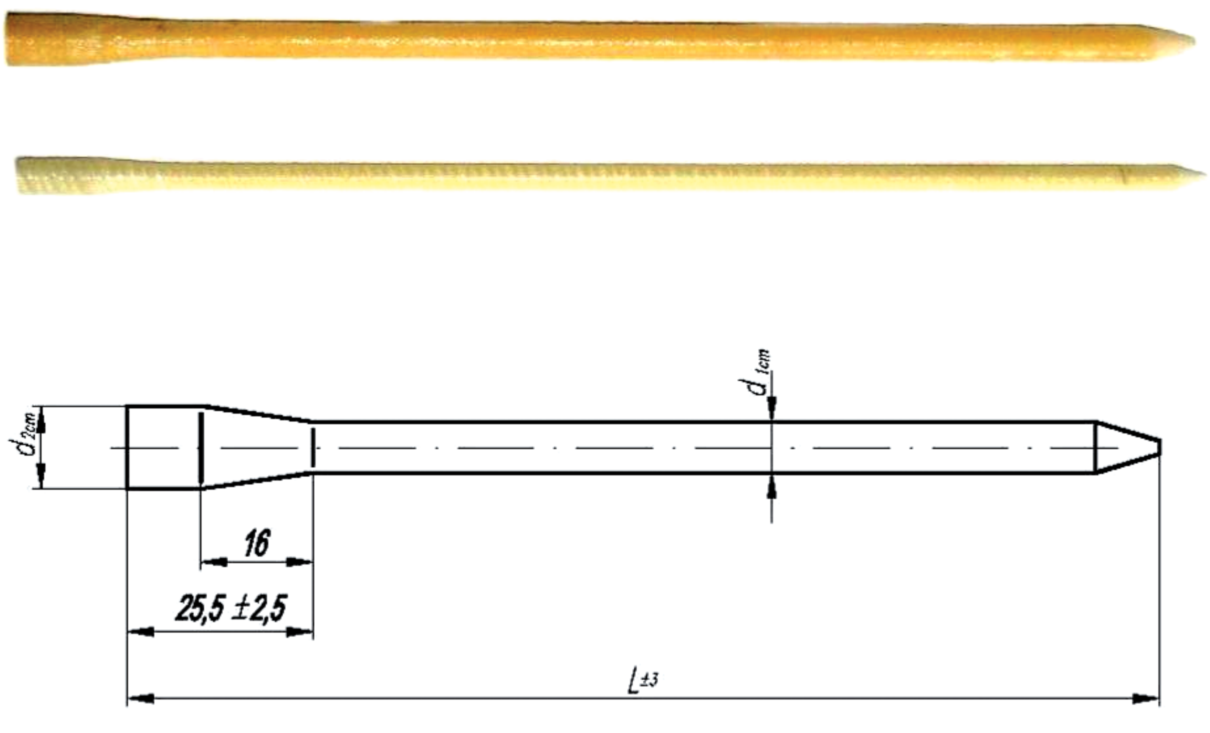


Fig. 1. Fiberglass dowel of CD-2 type. Surface appearance

Table 1

Cross-sectional parameters for CD-2 fiberglass dowel

Dowel Type	Identification (marking) RE	Size, mm	
		d_1	d_2
CD-2	RE-2	5.5±0.2	7.7±0.4

tests were conducted with reference to the methods of ETAG 001, close to the one rendered in Federal State Office "Federal Centre of Construction" [7] and used earlier in the tests of "Evrotest Ltd." [8] until a movement in the dowel anchored in the brick layer was detected.

Prior to verification tests, we conducted a series of trial runs, which were aimed at the following:

— optimizing the structure of the locking grip, which would enable the transfer of the pull-out force from the tester to the dowel stem;

— assessing the influence of Twinblock (produced by "Teplit Ltd.") strength on the pull-out strength value;

— assessing the influence of the paste used in Twinblock brick layering on the pull-out strength value.

Proceeding form the results of the trial tests, the following preconditions were made for further research:

1. The locking grip construction was agreed upon; it is based on the gripping nut and self-locking hooks; on one side, the nut was fixed on the anchor with the diameter of 5.2–5.5 mm on the other, it was held with a weld-on terminator, and then fixed in the Tester (Fig. 3). The test results showed that the component itself can hold the plastic anchor with strength values up to 4 kH, at which the anchor stops performing its function with elastic strain and consequentially, destructs (either though tear or irreversible elongation).

2. In trial tests it was found out that a Twinblock brand produced by "Teplit Ltd." (we conducted the research on blocks with the density of 500 kg/m^3 and 600 kg/m^3) does not significantly influence the pull-out strength values in anchoring elements of masonry (data dispersion was of non-systemic character).

It was stated that the paste brand seriously affects pull-out strength values; in view of this, there were two fragments of Twinblocks taken for brick layers, with density values of 400 kg/m^3 and 500 kg/m^3.

The masonry work was performed on two types of paste:

— based on dry mix Brozex ksb-17, "forced" (Dry mix plant "Brozex Ltd.");

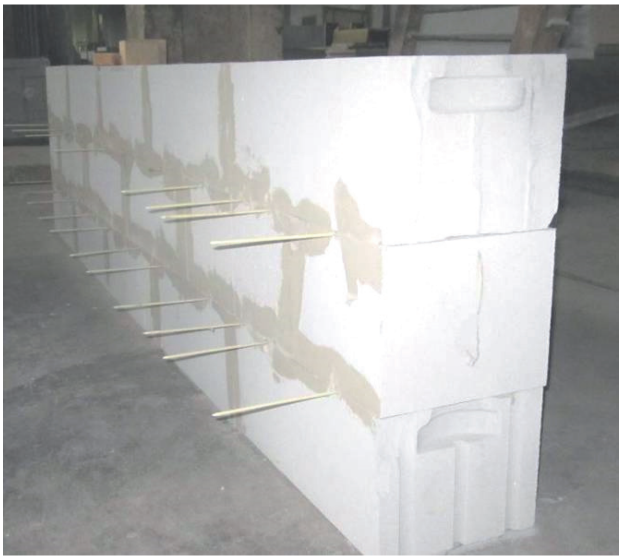
— based on dry mix "Twinblock KL" ("Teplit Ltd.")

To conduct the trials, two masonry fragments from Twinblock were prepared: a block layer of TB 400–5p on the paste prepared from "Twinblock KL", a block layer TB 300–4p on the paste prepared from dry mix Brozex ksb-17, "forced" (Dry mix plant "Brozex Ltd."). The dowels were laid with the reinforced end going into a specially prepared groove in a twinblock with a pasted brick joint, and afterwards they were covered with paste on top.

The sections with twinblock layers can be seen in Fig. 2.

When the tests were taken, the hardening time for masonry fragments amounted to 28 days. The tester working while laying twinblocks is shown in Fig. 3.

a)



b)

Fig. 2. Masonry fragments after the construction works are complete: a) block layers on the paste "Brozex"; b) block layers on the paste "Twinblock-KL"

Fig. 3. The tester working while laying twinblocks

If we exclude the extremes (minimum and maximum), we will arrive at the following mean values for dowel pull-out strength:

— 1.12 kN (111.9 kg) for laying twinblocks on the paste "Brozex";

— 0.294 kN (29.4 kg) for laying twinblocks on the paste "Twinblock-KL".

Fig. 4 shows a graph for the changes in dowel pull-out strength (paste "Brozex"), and Fig. 5, correspondingly, paste "Twinblock-KL".

with silicate facing hollow bricks produced at "SiMAT Ltd." on the ready-mixed brand M100.

The following method of fixing the dowel in the brick body was accepted:

— a hole is made in the brick with the bore of 10 mm in diameter;

— a polyamide anchor produced at "Biisk Fibreglass Plant Ltd." is inserted into the hole to its full length.

Fig. 6 shows fragments of masonry work with fiberglass dowels set in.

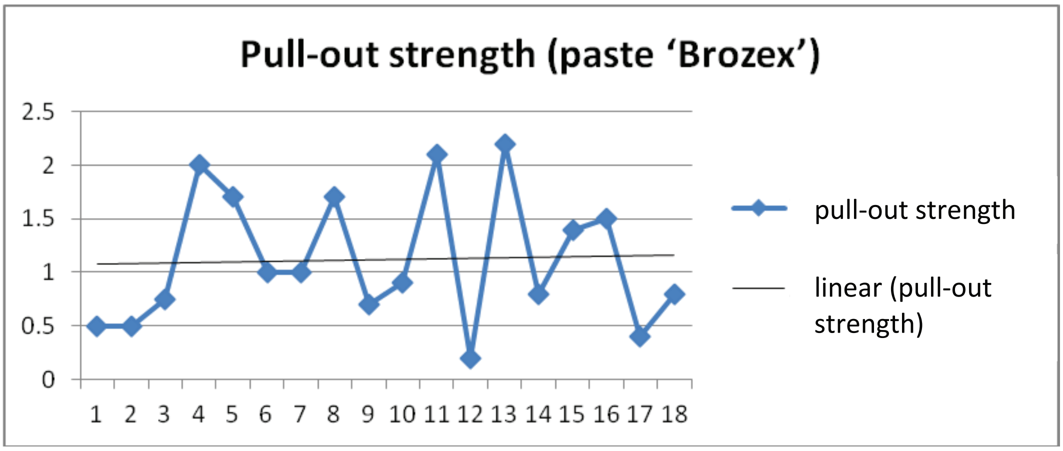


Fig. 4. Changes in dowel pull-out strength on paste 'Brozex'

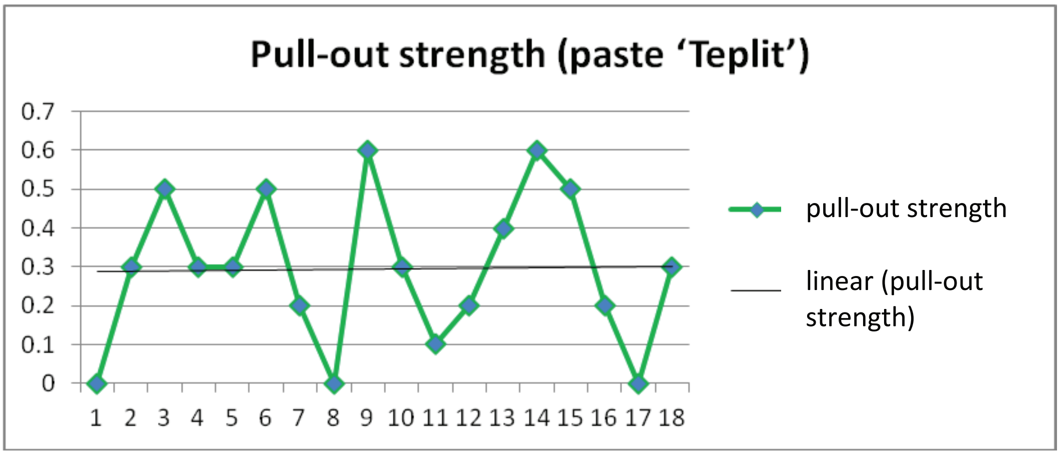


Fig. 5. Changes in dowel pull-out strength on paste "Tepilt"

Pull-out tests for brick layer dowels were conducted for three different ways of fixing the dowels in the brick layer:

— fixing the dowel inside the brick joint (while laying bricks);

— fixing the dowel inside the brick body with partial air voids (after the bricks were laid);

— fixing the dowel inside the brick body (after the bricks were laid).

The tests were performed on location on a building site in Yekaterinburg, where the masonry work as done

The general appearance and the shape of the polyamide anchor are shown in Fig.7, anchor sizes can be seen in Table 2 (as given in Tools, Jigs and Fixtures 20994511–001–2009 [4]).

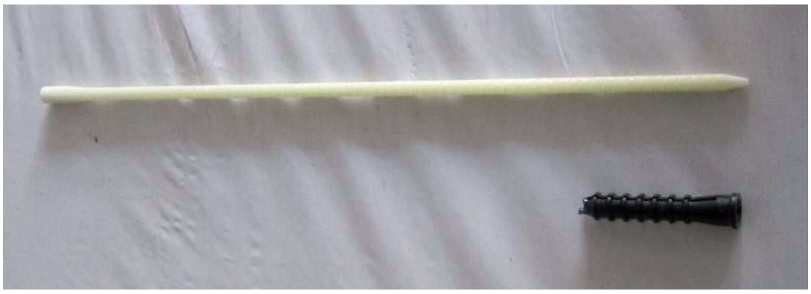
Table 2

Polyamide anchor sizes for the fiberglass dowel of CD-2 type

Dowel type	Anchoring element, brand	Sizes, mm					
		d_1	d_2	d_3	d_4	d_5	L
DC-2	AE 50	5.9	10.0	4.2	8.0	12.0	50.0

Fig. 6. Fragments of masonry work with fiberglass dowels set in:
1 — the dowel is fixed in the brick joints between layers;
2 — the dowel is fixed in the brick body (with air voids);
3 — the dowel is fixed in the brick body

a)



b)

c)

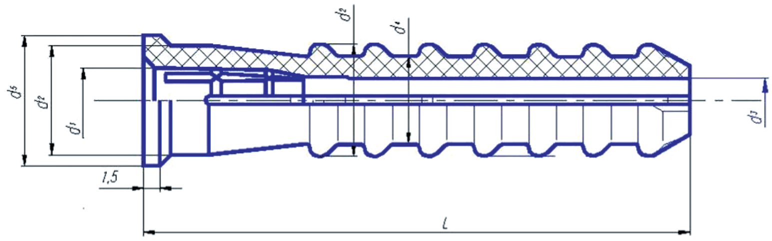


Fig. 7. Polyamide anchor:
a) fiberglass dowel and anchor; b) anchor in section (with smooth inner surface visible) c) anchor shape and geometry

When the tests were taken, the hardening time for masonry fragments amounted to 14 days. Every masonry type underwent a series of 20 trial tests.

The pull-out tests for the dowels fixed in the brick joints proved that pull-out resistance strength values are near zero. A dowel without resistance would jump the brick layer, sometimes when the standard instrument was being set in. Five measurements of this type were taken before they were discontinued on the grounds of inexpediency.

Having excluded the extremes (the minimum and the maximum), we arrive at the mean pull-out value for the dowel in the brick layer:

— the mean values when the dowel is fixed in the brick body with air voids is 0.106 kN (10.6 kg);

— the mean values when the dowel is fixed in the brick body is 0.589 kN (58.9 kg).

The line graph illustrating the changes in dowel pull-out strength is shown in Figs. 8, 9.

and outer walls. In the seismic regions of Russia it is also necessary to conduct further anchor testing to measure the effect of dynamic load that would copy seismic activity in accordance with the methodology worked out in TSNIISK of V. A. Koucherenko (State Research Institute of Construction and Design) [6].

This methodology ensures the stability of construction and the reliability experimental data and maximizes the on-load potential to real-life load capacity during earthquakes.

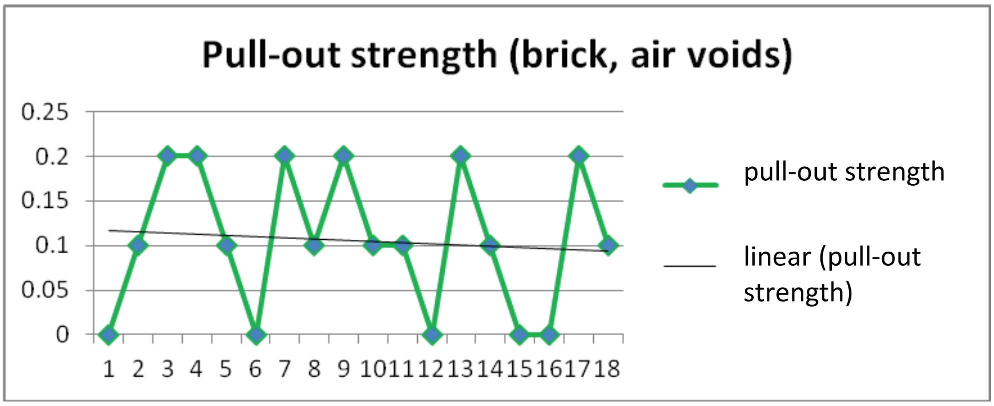


Fig. 8. Changes in dowel pull-out strength from masonry when the dowel hits a void

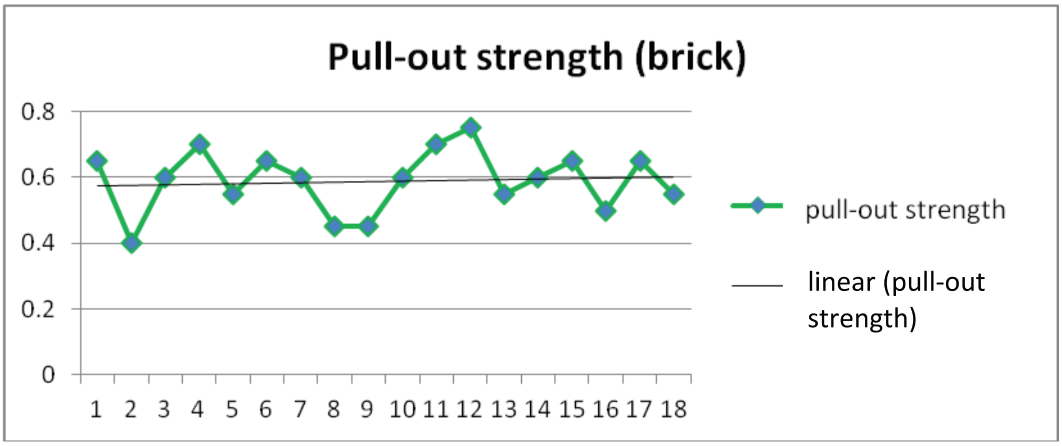


Fig. 9. Changes in dowel pull-out strength from masonry when the dowel is fixed in the brick body.

Conclusions

We gathered new experimental data about the on-load operation of fiberglass elements, which are used as flexible connectors in walling set up in the Ural region.

We concluded that laying dowels in brick joints when finishing the external row of walling is non-admissible due to low value of pull-out resistance strength.

The results received experimentally generally correspond with those gathered on location, which were earlier performed by “Evrotest Ltd.” to the order of “Biisk Fiberglass Plant” in Moscow [8].

When designing the walling type under consideration, we recommend using the results of the trial tests to locate the positions for anchoring dowels to connect inner

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